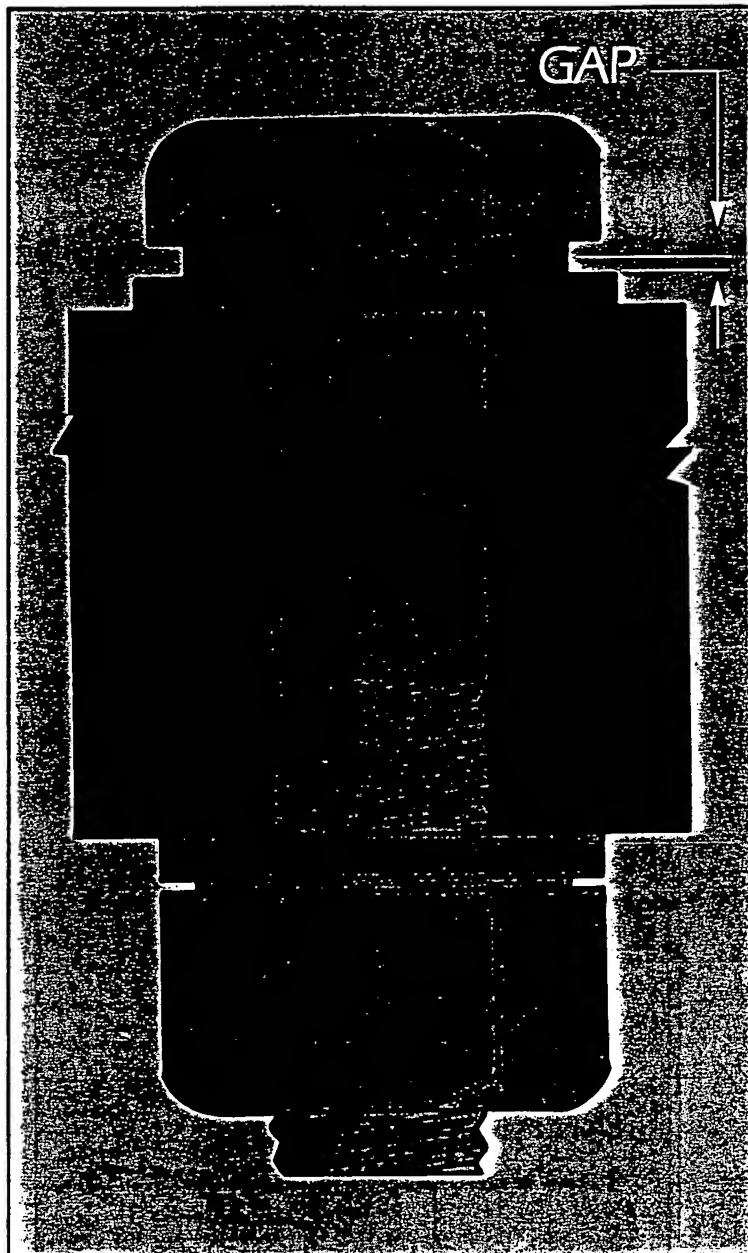
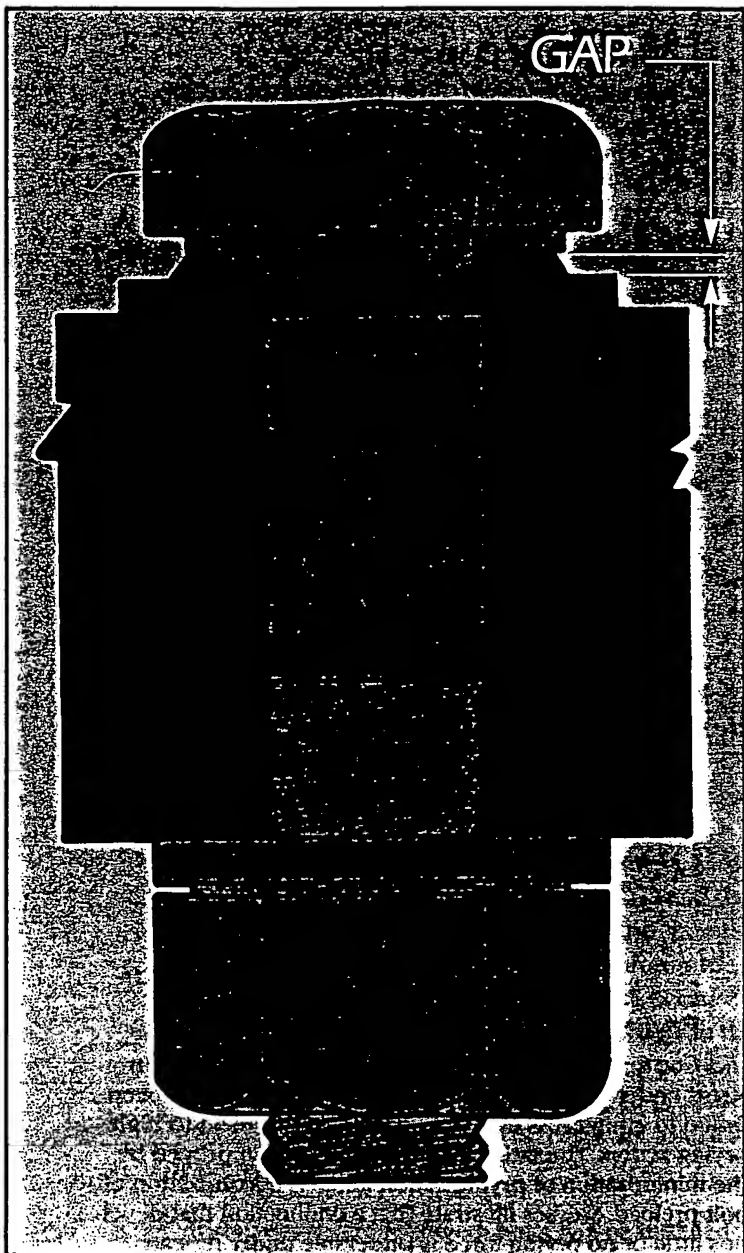


Beth-Fast **Direct Tension Indicators**

The last word in proper structural bolt installation.
Reduce the cost of inspection.



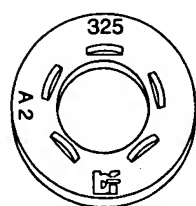
Direct Tension indicators Manufactured to ASTM F959 For Use with A325 or A490 High Strength Bolts
Made in U.S.A.

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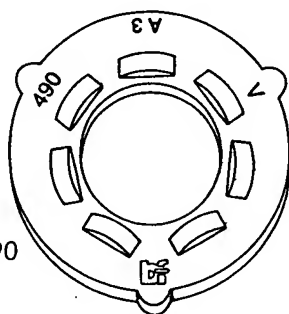
The Beth-Fast **DIRECT TENSION INDICATOR**

Usually known as a DTI, the Beth-Fast Direct Tension Indicator is a specially produced washer shaped device with protrusions pressed out of the flat surface.

The Beth-Fast DTI meets the requirements of ASTM F959, and the definition of a Direct Tension Indicator, as established by the "Specification for Structural Joints Using ASTM A325 or A490 Bolts" of the Research Council on Structural Connections of the Engineering Foundation, and endorsed by the American Institute of Steel Construction and The Industrial Fasteners Institute.



Type 325



Type 490

HOW DTIs WORK

A Direct Tension Indicator is placed on a bolt with the protrusions bearing against a hardened surface in the bolt-nut-hardened flat washer assembly, usually under the washer face of the bolt head as shown in Figure 1. Note the obvious gap between the DTI and the bolt head.

As the bolt and nut are tightened, the clamping force flattens the protrusions and reduces the gap. When the gap is reduced to the required dimension, the bolt is properly tightened.

Inspection is performed quickly and easily by measuring the average gap with a metal feeler gage.

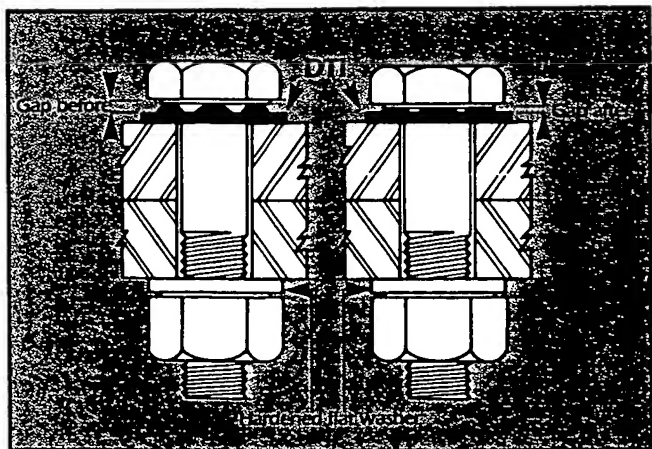


Figure 1

DTIs REPLACE OTHER METHODS

"Turn of Nut" and "Calibrated Wrench" methods are not reliable and are difficult to inspect or verify that they have been used.

These installation methods do not produce a uniformly consistent tensioning of the bolts. Effects of bolt length, thread condition, and bolt/nut assembly performance usually make these methods difficult and inaccurate to apply in the field, resulting in poor consistency of bolt tension.

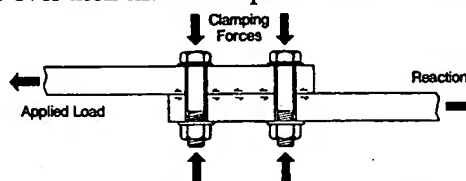
Twist-off bolts measure torque or twist. Like a calibrated wrench the twist-off aspect is not a measure or assurance of bolt tension.

ADVANTAGES OF BETH-FAST DTIs

Direct Tension Indicators control bolt tension. The proper tensioning of bolts is good engineering practice and provides the following benefits.

Connections Don't Slip

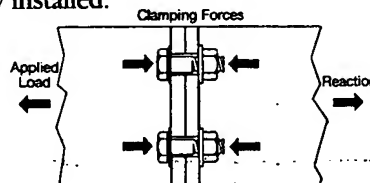
All connections deemed slip-critical must not slip. Taking into account the slip factor, engineers design for a clamping force that will prevent a connection from slipping at service loads. This is achieved by tensioning the bolts to over their minimum specified tension. See table 1.



DTIs ensure connections don't slip

Stress Cycles are "Captured"

Installed bolt problems have occurred in connections where the bolts were subjected to repeated cycles of tension loads greater than the installed bolt tension. Problems are either loosening of bolts and nuts or with less ductile fasteners, fatigue fracture. The maximum permitted stress cycle of 60% of bolt preload will not be exceeded if bolts are properly installed.



DTIs make sure cycles of stress on bolts are contained.

Prying Action Effects are Minimized

Correctly tensioned bolts sense very little change in stress under prying loads. The presence of a DTI has been found to inhibit loss of pretension in bolts subject to high prying action. The fatigue life of fasteners is improved by the minimization of prying action and the maximization of bolt preload. Studies illustrate that a connection that develops little or no prying force is preferable under repeated loading.

DTIs help minimize effects of prying action.

Improves Structural Rigidity

Properly tensioned fasteners will absorb energy and dampen a structure against movement caused by wind or seismic loading. Properly clamped connections benefit structural rigidity.

DTIs provide tension for a rigid connection.

Tests the Fasteners for Conformance

If a bolt and nut can be installed to beyond its minimum required tension, this is a significant test as to the quality of the bolt and nut assembly. It shows that the lubrication was satisfactory, that the nut did not strip or "freeze" before the bolt had reached the required degree of tension. It proves that the bolt did not plastically deform or "give up" below the proper tension due to sub-standard material or incorrect manufacturing.

DTIs help check the quality of a fastener assembly.

DIRECT-TENSION INDICATORS ARE AN INCOMPARABLE AID TO INSPECTION

Beth-Fast DTIs Reduce the Costs of Inspection

Beth-Fast DTIs provide a cost-effective "silent inspector" in the grip of each installed fastener. They remain a permanent witness that the bolt has been correctly installed. Their up-front cost is insignificant, yet they can save several dollars a ton because DTIs replace traditional inaccurate and cumbersome calibrated wrench inspection practices. Inspection is much quicker, cheaper and simpler with DTIs.

Beth-Fast DTIs are Safer for Inspectors

It is well known that calibrated wrench inspection is often hazardous to inspectors. Inspectors have been injured and even cases of fatalities have been recorded. As DTI inspection is purely visual, and ironworkers generally compress them to an acceptable gap dimension, inspection is significantly safer.

DIRECT-TENSION INDICATORS ARE AN AID TO IRON WORKING CREWS

Gaps can be Judged by EYE

With practice, bolters can learn to readily judge each gap by eye, then check one or two with the feeler gage before leaving the connection.

In addition to the ease and speed of inspection, there is another money-saving benefit of DTIs: there's no need for an employee to operate the torque wrench for the inspector.

DTIs

- **Eliminate rejections and "call-backs"**
Because the bolting crews can check their work, there should be no rejections by inspectors, and no costly returns to retighten bolts.
- **Provide a record**
When a bolt is properly tightened, the DTI is permanent proof of reliable iron worker bolting practices.
- **Are accurate—and consistently so**
When the bolt is tightened to the required average gap, bolt tension will be equal to, or greater than, the minimum value required by specification. See Table 1.
- **Are versatile**
Direct Tension Indicators can be used under the bolt head, or at the nut end. The nut-end assembly can be used with countersunk-head bolts, or when it is too difficult to see and reach the bolt-head side for inspection.
- **And, easy to use**
Standard wrenches and sockets are used for tightening. No special tools and no tedious calibration are required. Experienced bolters can easily develop a technique that will quickly tighten the bolts after snugging.

AVAILABILITY OF BETH-FAST DTIs

- **Available in plain (uncoated) finish:**
For A325 Type 1 bolts in diameters from 1/2" through 1 1/2"
For A490 Type 1 bolts in diameters from 3/4" through 1 1/2".
- **Available in Mechanically Galvanized finish (to ASTM B 695 Class 50):**
For A325 Type 1 Hot Dip or Mechanically Galvanized bolts in diameters from 1/2" through 1 1/2".
- **Available in Epoxy on Mechanically Galvanized finish:**
For use with A325 Type 3 bolts in diameters from 1/2" through 1 1/2".

HOW TO SPECIFY

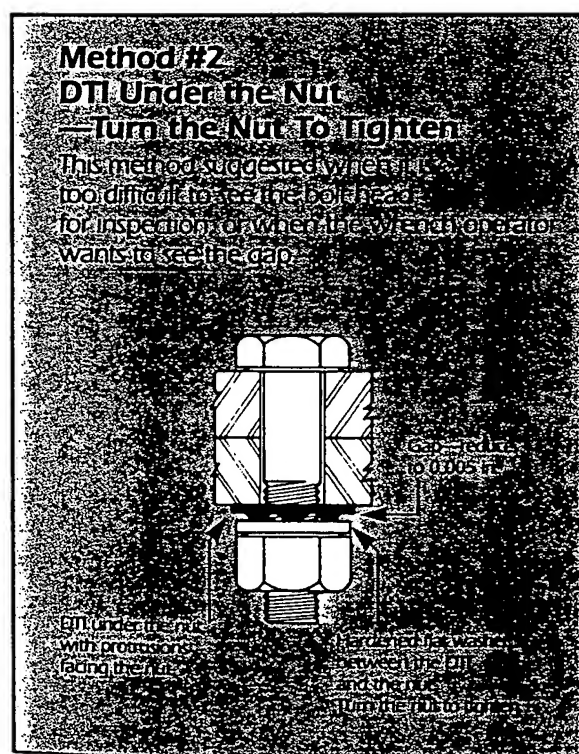
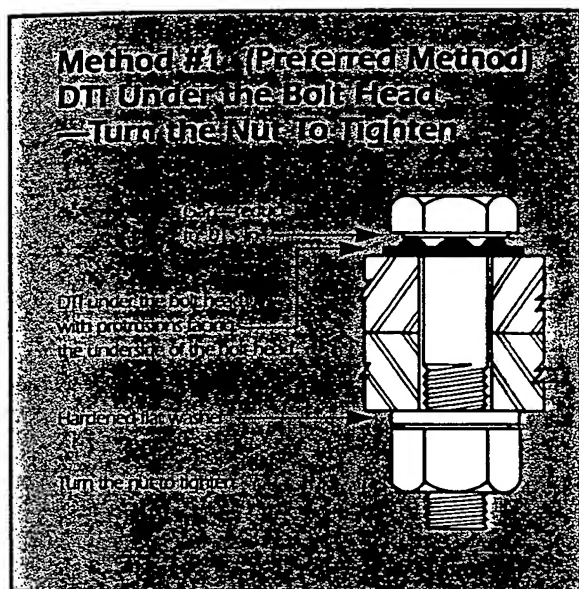
- Simply extend the ASTM specification. Direct Tension Indicators must be specified in project specification in order to make certain that they will be used. The specification should read as follows:

"All A325 and A490 High Strength bolts shall be tightened and inspected using Direct Tension Indicators to the latest ASTM F959."

It is as simple as that.

The BethFast **DIRECT TENSION INDICATOR**

INSTALLATION



These are the three basic combinations for placing the DTI and turning an element of the assembly. Note that a smaller gap (0.005 in.) is required when the DTI is used on the turned-element side.

- The protrusions of the DTI must always bear against a hardened surface—either the washer face of the bolt head or a hardened flat washer, but *never* against the steelwork or the nut.
- When the DTI is used on the turned-element side of the assembly, a hardened flat washer must be placed between the protrusions of the DTI and the turned element. This minimizes “smearing” the protrusions, which would close the gap before the bolt is properly tightened. Some movement of the hardened flat washer during tightening is acceptable. Because of the possibility of some smearing of the protrusions, the gap requirement for this assembly is 0.005 in.
- When the DTI is used under the non-turned element, the surface contacting the protrusions should not turn during tightening. Holding the non-turned element with a hand wrench is the best way to accomplish this.
- When mechanically galvanized or epoxy coated DTIs are used, the gaps should be closed to 0.005 in. under the bolt head or to nil at least half way round under turned element.
- Allow 1/4" on bolt length for installed DTI and hardened washer.

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Basic installation pointers for properly installing A325 and A490 bolts with DTIs.

- A hardened flat washer should be used under the turned element to prevent galling the contact surfaces.
- Properly fit-up a connection by drawing together the plies of steel before completing the tightening of any bolts. Snug the bolts by partially compressing the DTI protrusions. This will put more than half the tension on each bolt which should fully compress the plies before final tightening. Connections with several plies, with heavy steel, or a bad fit, may need more than one snugging pass.
- When snugging and tightening the bolts and nuts, always work from the fixed or rigid points to the free edges.
- The non-turned element should be held with a hand wrench during tightening.
- Keep bolts well lubricated and free from thread damage. Use Chem-Trend Stick wax #140 or equivalent on bolts 1" or over in diameter.
- Make sure wrenches are in good condition and are of the right capacity (at least a CP 6120 or equivalent on bolts 1" or over in diameter). Air pressure should be maintained at 100 PSI.
- The special washer requirements of the Research Council specification—such as those for slotted or oversized holes—must be observed. The DTI *may not* be substituted for these required washers, but *must* be used with them. On over 1" A490 bolts ASTM F436 washers are to be at least 5/16" thick.
- If DTIs are installed under the turned element, hardened washers are required between the DTI and the turned element to prevent "wearing" of the "bumps" Check that the washer hole diameter conforms to ASTM F436 for sizes up to 7/8". Above 7/8", because ASTM F436 allows a washer I.D. 1/8" greater than the diameter of the bolt, which could expose a portion of the DTI "bumps," it will be necessary to produce washers made for use with DTIs. These are available from Beth-Fast.

If above rules are followed, bolts will be installed in less than 10 seconds and they are less likely to fracture during installation.

INSPECTION

Use the correct thickness feeler gage—either 0.015 in. or 0.005 in.—as a "no go" inspection tool. See Table 1.

Table 1. DTI Gages to Measure Minimum Bolt Tension	
DTI Location	Gage
Away from turned element—see Method #1	0.015 in.
Adjacent to turned element—see Methods #2 & #3	0.005 in.
For mechanically Galvanized with and without epoxy (A325 only) Method #1	0.005 in.

Note: If installed under turned element—coated DTIs should be compressed to nil gap at least half way around.

To get a true reading, one should try to insert the pointed nose of the gage into the opening between adjacent, flattened protrusions as shown in Figure 2. Zero gap is acceptable on A325 bolts but should be avoided where possible on A490 bolts.

Inspection should always be based on the *average gap*. The *average gap* is not a calculated average determined from several measurements. To measure *average gap*, simply make certain the gage refuses to enter the number of spaces per Table 2.

Table 2				
Bolt Size	Minimum Bolt Tension (kips)	Minimum Tensile Strength (kips)	DTI Spaces	DTI Entries/Refusals
Type 325				
1/2"	12	17	4	2
5/8"	19	27	4	2
3/4"	28	40	5	3
7/8"	39	55	5	3
1"	51	73	6	3
1 1/8"	56	80	6	4
1 1/4"	71	102	7	4
1 3/8"	85	121	7	4
1 1/2"	100	148	8	4
Type 490				
3/4"	35	50	6	3
7/8"	49	69	6	3
1"	64	91	7	4
1 1/8"	80	114	7	3
1 1/4"	102	145	8	4
1 3/8"	121	173	8	4
1 1/2"	148	211	9	5

When the gage is refused in the proper number of spaces the bolt is tightened to at least the minimum bolt tension, Table 2.

TESTING THE DTI/BOLT ASSEMBLY

Research Council on Structural Connections requires that a bolt tension calibrator be provided at every job site where bolts are to be tightened. It is to be used to verify the suitability of the complete fastener assembly, including the method of tightening.

The verification test when DTIs are used proceeds this way. Assemble the bolt, nut, washer and DTI in the calibrator as shown in Figure 2. Then tighten the bolt to the Minimum Bolt Tension given in Table 2 and check to see that right feeler gage, Table 1, can enter at least the number of spaces given in Table 2. The load should be increased as smoothly as possible so as to avoid "fallback," which occurs when the load cell "bleeds off" and the calibrator shows a lower load than the actual bolt load. It has now been shown that the assembly reaches the minimum tension prior to closing of the minimum number of gaps needed to be closed for acceptance.

Next the bolt should be tightened to the point where the feeler gage refuses to enter the number of spaces in Table 2. At this point the tension in the bolt measured by the calibrator must be less than the Minimum Tensile Strength given in Table 2. It has now been shown that the tension in the bolt will not exceed the minimum tensile strength of the bolt when the proper number of gaps are closed.

Always make sure that there is a document with the bolt tension calibrator which certifies that it has been calibrated by devices traceable to the National Institute of Standards and Technology within the last year.

TESTING DTIS

Beth-Fast will supply upon request "certificates of compliance" for its DTIs which certify that they are in conformance with the requirements of ASTM F959.

Do not try to perform the ASTM Performance Test. This test, which must be performed by the manufacturer in order to issue a "certificate of compliance," requires special apparatus and should be performed in a qualified test laboratory.

Copies of the latest ASTM F959 are available from Beth-Fast.

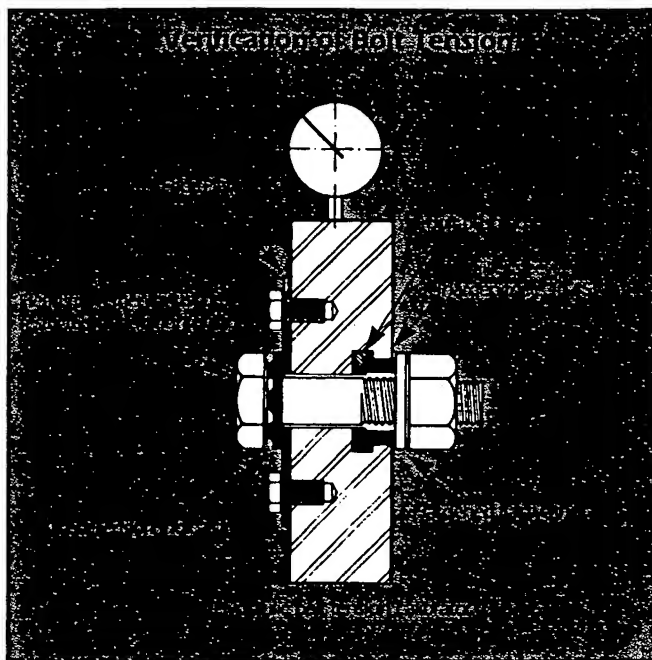


Figure 2

PLEASE REMEMBER

The DTI does not make it more difficult to tighten a bolt and nut. But, it does show that the connections have been tightened properly—and that makes it easier.

The DTI is a precision-made device and should never receive any treatment after leaving our plant.

DTIs should not be reused.

Direct Tension Indicators save far more money than they cost. And, the contractor and the owner get a free bonus in the confidence that the bolts are properly tightened.

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